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# 2

91164



911640



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## Level 2 Chemistry, 2016

### 91164 Demonstrate understanding of bonding, structure, properties and energy changes

9.30 a.m. Monday 21 November 2016  
Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

**You should attempt ALL the questions in this booklet.**

A periodic table is provided on the Resource Sheet L2-CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–10 in the correct order and that none of these pages is blank.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**

**Excellence**

TOTAL

**23**

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## QUESTION ONE

- (a) Instant cold packs are useful for treating sports injuries on the field. They contain salts such as ammonium nitrate,  $\text{NH}_4\text{NO}_3$ . When the packs are activated, the salt dissolves in water, causing the temperature to decrease.

Circle the term that best describes the dissolving process.

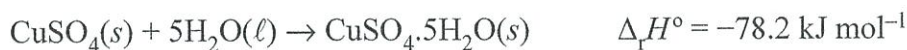
endothermic

exothermic

Give a reason for your choice.

The cold packs absorb heat energy from surroundings

- (b) The equation for hydrating anhydrous copper sulfate is as follows:



Circle the term that best describes this reaction.

endothermic

exothermic

Give a reason for your choice.

The enthalpy value is negative which means energy is being released.

- (c) Pentane,  $\text{C}_5\text{H}_{12}$ , is a liquid at room temperature. It evaporates at  $36.1^\circ\text{C}$  in an endothermic process.

- (i) Explain why the evaporation of pentane is an endothermic process.

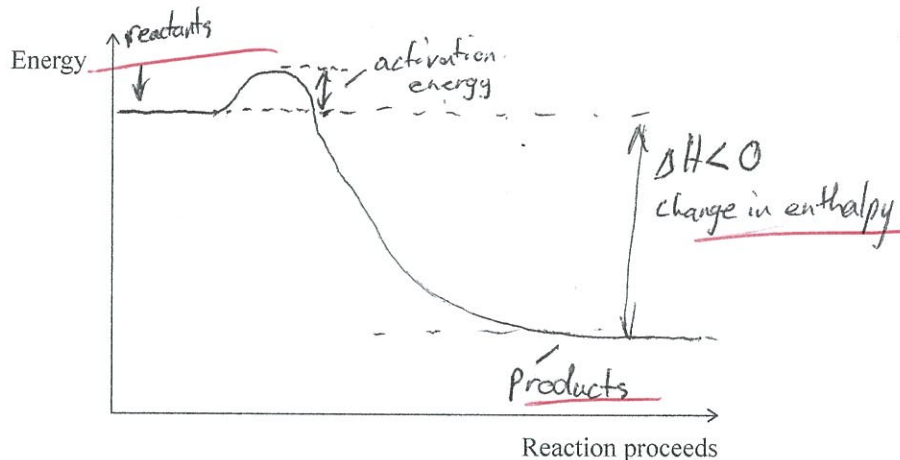
The evaporation process is endothermic because the particles in the pentane liquid require heat energy to overcome the weak intermolecular forces between the molecules, and therefore the energy absorbed gives the particles more kinetic energy to break the ~~bonds~~ weak attractions.

- (ii) Draw, including labels, the energy diagram for the combustion of pentane,  $C_5H_{12}(l)$ .

Pentane combustion:

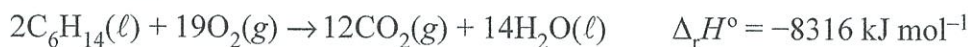


Include in your diagram the reactants, products, and change in enthalpy.



- (iii) Hexane,  $C_6H_{14}$ , like pentane, will combust (burn) in sufficient oxygen to produce carbon dioxide gas and water.

Hexane combustion:



Justify which alkane – pentane or hexane – will produce more heat energy when 125 g of each fuel is combusted in sufficient oxygen.

$$M(C_5H_{12}) = 72.0 \text{ g mol}^{-1}$$

$$M(C_6H_{14}) = 86.0 \text{ g mol}^{-1}$$

$$1 \text{ mol pentane} \rightarrow -3509 \text{ kJ mol}^{-1}$$

$$2 \text{ mol hexane} \rightarrow -8316 \text{ kJ mol}^{-1}$$

$$n = \frac{m}{M} \quad n = \frac{125}{72} \quad n = \frac{125}{86} = 1.45 \text{ mol}$$

$$1 \rightarrow -3509$$

$$\frac{125}{72} \rightarrow \Delta H$$

$$1.736$$

$$\Delta H = 54828.125 \text{ kJ mol}^{-1}$$

$$\text{pentane} = 54800 \text{ kJ}$$

$$\text{pentane} = 6092 \text{ kJ}$$

$$= 6090 \text{ kJ}$$

energy released

$$n = \frac{m}{M}$$

$$n = \frac{125}{86}$$

$$n = 1.45 \text{ mol}$$

$$2 \rightarrow 8316$$

$$1.45 \rightarrow E$$

$$E = 6043.6 \text{ kJ}$$

$$\text{hexane} = E = 6040 \text{ kJ energy released}$$

Pentane has more energy released than Hexane

$$6090 \text{ kJ} > 6040 \text{ kJ}$$

## QUESTION TWO

- (a) Complete the table below by stating the type of substance, the type of particle, and the attractive forces between the particles in the solid for each substance.

Substance	Type of substance	Type of particle	Attractive forces between particles
ZnCl <sub>2</sub> (s) (zinc chloride)	<u>Ionic</u>	<u>Ion</u>	<u>Ionic bond</u>
C(s) (graphite)	<u>Giant covalent network</u>	<u>atom</u>	<u>Strong covalent bonds</u>
CO <sub>2</sub> (s) (carbon dioxide/dry ice)	<u>Molecular</u>	<u>molecule</u>	<u>weak intermolecular forces</u>

- (b) Carbon (graphite) conducts electricity when it is solid, whereas zinc chloride, ZnCl<sub>2</sub>, will not conduct electricity when solid, but will conduct when molten.

Justify this statement in terms of the particles, structure, and bonding for both substances.

Graphite is a giant covalent network which is made up of carbon atoms <sup>covalently</sup> bonded to three others in a trigonal planar shape. There is one delocalised valence electron which bonds between the layers <sup>delocalised</sup> sheets. ~~These~~ These valence electrons are free to move and can therefore conduct electrical charge ~~through the~~ <sup>through the</sup> whole solid. //

ZnCl<sub>2</sub> is an ionic substance which is in the form of a 3D lattice while solid with alternating positive (Zn<sup>2+</sup>) ions and negative (Cl<sup>-</sup>) ions. These ions are held together by strong electrostatic attractions and cannot move. This is why ZnCl<sub>2</sub> cannot conduct electricity while solid. When ZnCl<sub>2</sub> is a liquid or in solution, the ions are free to move about and can transfer electrical influence through the substance. //

- (c) Solid zinc chloride,  $\text{ZnCl}_2(\text{s})$ , is soluble in water. Dry ice,  $\text{CO}_2(\text{s})$ , is not readily soluble in water.

Justify these statements in terms of the particles, structure, and bonding of these substances. You may include a diagram or diagrams in your answer.

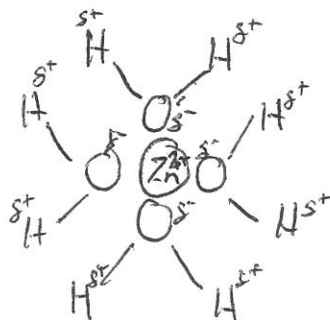
$\text{ZnCl}_2$  is an ionic substance. When in solution, the polar water molecules can interact with the ions pulling them apart. The  $\delta^+$  H atom attracts the  $\text{Cl}^-$  ion and the  $\delta^-$  O atom attracts the  $\text{Zn}^{2+}$  ion. Therefore  $\text{ZnCl}_2$  is soluble in water. ||

$\text{CO}_2$  is a molecular substance which is held together by weak intermolecular forces.  $\text{CO}_2$  is a non-polar molecule due to its symmetrical nature and does not split apart into ions when in solution. The polar water molecules cannot interact with the molecule so  $\text{CO}_2$  will not readily dissolve in water. ||

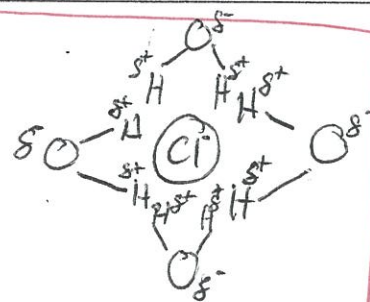
Space for diagrams



Solid  $\text{ZnCl}_2$



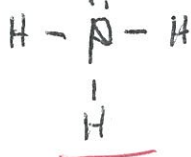


dissolved in  $\text{H}_2\text{O}$



## QUESTION THREE

- (a) (i) Draw the Lewis structure (electron dot diagram) for each of the following molecules, and name their shapes.

Molecule	H <sub>2</sub> O	CS <sub>2</sub>	PH <sub>3</sub>
Lewis structure			
Name of shape	<u>Bent</u>	<u>linear</u>	<u>Trigonal pyramidal</u>
Approximate bond angle around the central atom	109.5°	180°	109.5°

- (ii) Compare and contrast the shapes and bond angles of H<sub>2</sub>O, CS<sub>2</sub> and PH<sub>3</sub>.

H<sub>2</sub>O has four regions of negative charge around the central O atom which repel for maximum separation into a tetrahedral shape with bond angles of about 109.5°. There are two bonding regions and two non-bonding regions so the overall shape is Bent. ||

PH<sub>3</sub> is similar to H<sub>2</sub>O in that there are four regions of negative charge around the central P atom. They repel for maximum separation into a tetrahedral shape with bond angles of about 109.5°. However, PH<sub>3</sub> has three bonding regions and 1 non-bonding region so the overall shape is Trigonal pyramidal. ||

CS<sub>2</sub> has two regions of negative charge around the central C atom which repel for maximum separation into a linear shape with bond angles of 180°. Both regions are bonding regions so the overall shape is linear. |||

(b) The Lewis structures for two molecules are shown.

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Molecule	$\begin{array}{c} \text{H}-\ddot{\text{N}}-\text{H} \\   \\ \text{H} \end{array}$ Ammonia	$\begin{array}{c} \text{H}-\text{B}-\text{H} \\   \\ \text{H} \end{array}$ Borane
Polarity of molecule	polar	non-polar

Ammonia,  $\text{NH}_3$ , is polar, and borane,  $\text{BH}_3$ , is non-polar.

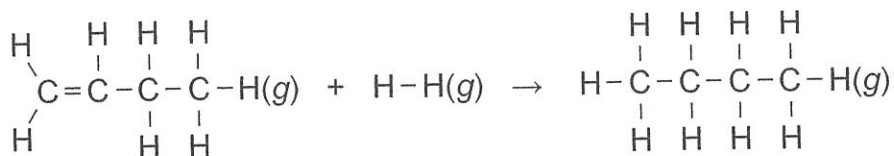
Justify this statement.

Ammonia has four regions of negative charge around the central N atom. Three of these are bonding regions and 1 is nonbonding. The overall shape is trigonal pyramidal with bond angles of  $109.5^\circ$ . There are three polar N-H bonds because N is more electronegative than H. The  $\text{NH}_3$  molecule is asymmetric so the effects of the bond dipoles ~~cancel~~ do not cancel and the molecule is therefore polar. //

$\text{BH}_3$  has three areas of negative charge which repel for maximum separation around the central B atom. All regions are bonding regions so the overall shape of  $\text{BH}_3$  is trigonal planar with bond angles of  $120^\circ$ . There are 3 polar B-H bonds due to the difference in electronegativity. The  $\text{BH}_3$  molecule is symmetrical so the effects of the bond dipoles cancel and  $\text{BH}_3$  is overall non-polar. //

- (c) Calculate the enthalpy change,  $\Delta_r H^\circ$ , for the reaction of but-1-ene gas,  $C_4H_8(g)$ , with hydrogen gas,  $H_2(g)$ , to form butane gas,  $C_4H_{10}(g)$ .

Use the average bond enthalpies given in the table below.



Bond	Average bond enthalpy / $\text{kJ mol}^{-1}$
C=C	614
C-C	346
C-H	414
H-H	436

Show your working and include appropriate units in your answer.

$$\Delta_r H^\circ = \sum E_{\text{bonds broken}} - \sum E_{\text{bonds formed}}$$

$$\Delta H = (614 + 436) - 2(414) + 346$$

$$\Delta H = 1050 - 828 + 346$$

$$\cancel{1174} = 1050 - 1174$$

$$\Delta_r H^\circ = -124 \text{ kJ mol}^{-1}$$



# Annotated Exemplar

Excellence exemplar 2016

Subject:	Chemistry	Standard:	91164	Total score:	23
Q	Grade score	Annotation			
1	E8	Both parts (a) and (b) are correct. Heat energy absorbed and intermolecular bonds in part (c)(i) are correct. In part (c)(ii), the graph is drawn correctly and is fully labelled. The energy calculations are correct and an appropriate conclusion is given in (c)(iii).			
2	E7	The table is correct in part (a). Conductivities of both graphite and $\text{ZnCl}_2$ are justified in part (b). In part (c), the attractions are included for $\text{ZnCl}_2$ but the response does not refer to the relative strengths of the attractions. Also it is stated that $\text{H}_2\text{O}$ and $\text{CO}_2$ cannot interact.			
3	E8	The table is correct in part (a)(i). The shapes are correctly explained in (a)(ii). The candidate's response about $\text{PH}_3$ demonstrates both a comparison and a contrast. In part (b), the electronegativity difference between B and H is holistically inferred for $\text{BH}_3$ . The calculation is correct in part (c).			